Design of an experimental set-up for the measurement of LET distributions

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RADiation and Reliability Challenges for Electronics used in Space, Aviation, Ground and Accelerators (RADSAGA) is a project funded by the European Commission under the Horizon2020 Framework Program under the Grant Agreement 721624.
RADSAGA began in Mars 2017 and will run for 5 years.

Presentation outline

- Project outline
- Detectors
- Design of the experimental set-up
- Construction
- Summary and outlook

Project

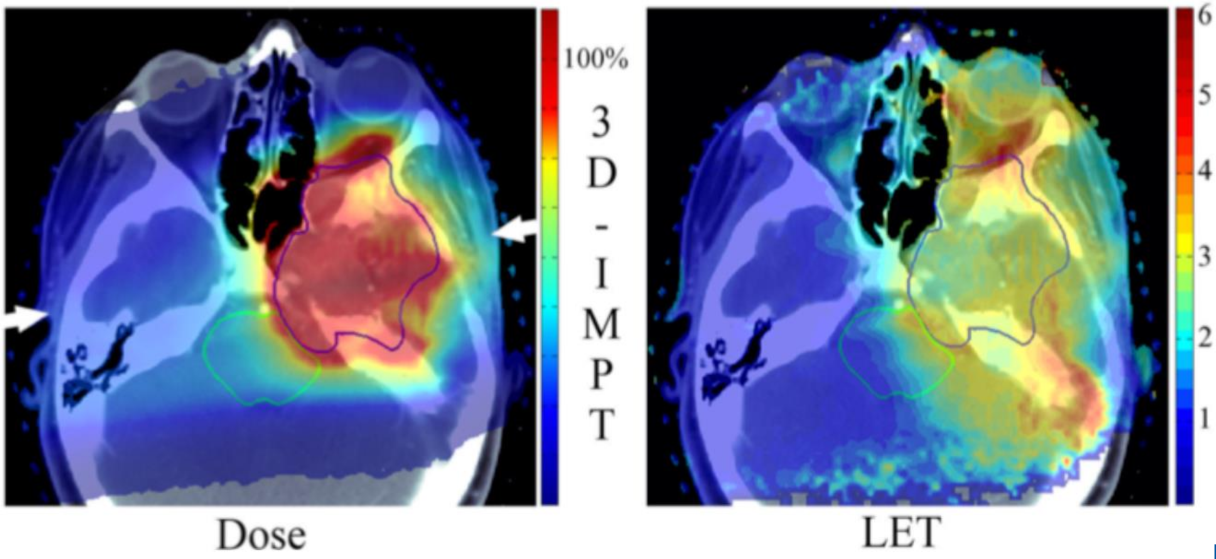
- Measurement and simulation of LET distributions
  - Linear energy transfer: $LET = \frac{dE}{dx}$
  - Geant4 and Fluka

- Comparison of different types of thin semiconductor detectors
  - Increased accuracy with thinner geometries
  - Measurement of non-primary particles

- Relation of LET to SEE rates

Clinical relevance

- High dose area is not necessarily an area of high LET



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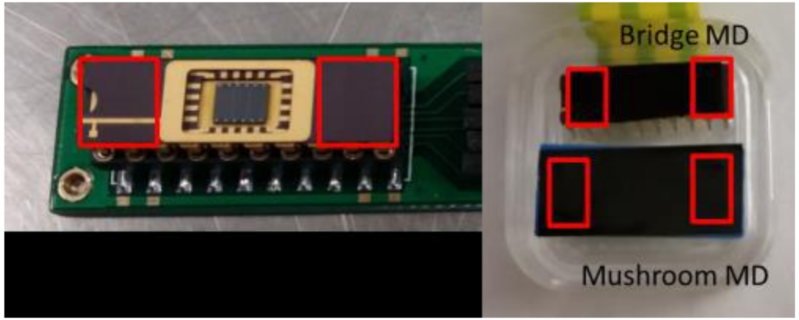
Detectors

- **Measurement of LET distributions:**
  - Silicon detector:
    - 3D Mushroom detector (CMRP)
    - d = 10 µm
  - Diamond detector:
    - PTW microDiamond
    - d = 1 µm



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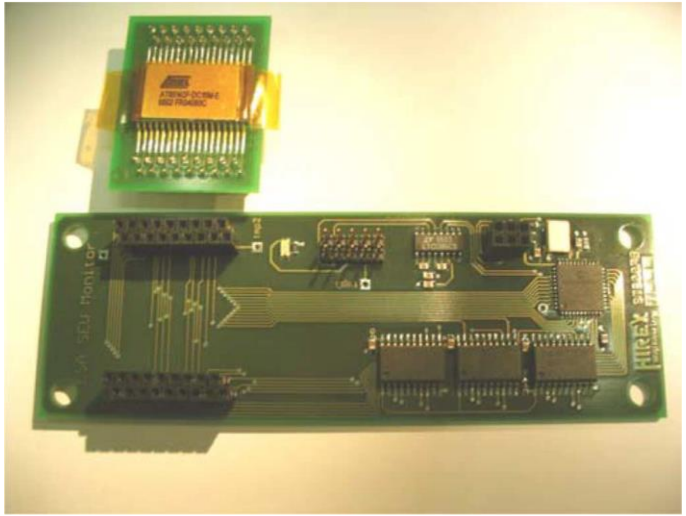
Detectors

- **Measurement of SEU: ESA SEU monitor**
  - Reference monitor for SEU measurements
  - Different test patterns can be loaded



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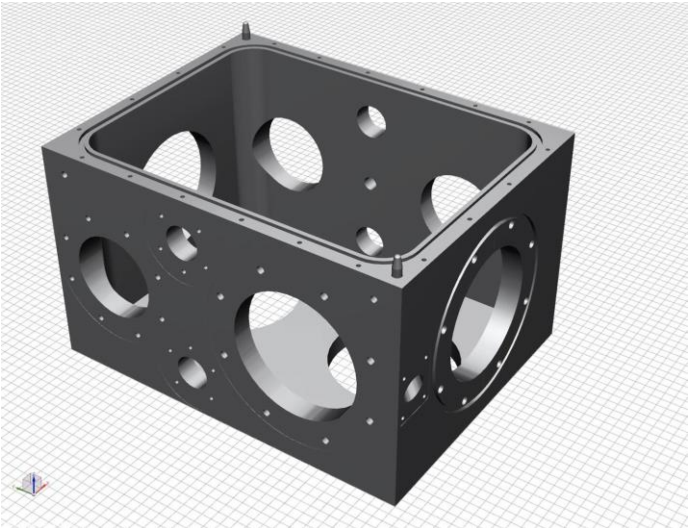
Design of the experimental set-up

- **Proposed experiments:**
  - **Measurement of LET distributions:**
    - Determination of applicability of Mushroom and microDiamond detector
    - Measurement in proton and heavy ion beams up to Bi in vacuum
  - **Measurement of SEEs:**
    - Special attention paid to sub-LET-threshold SEEs
    - Measurement with various thin foils in front of the detector
      - non-semiconductor materials found in chips, e.g. W

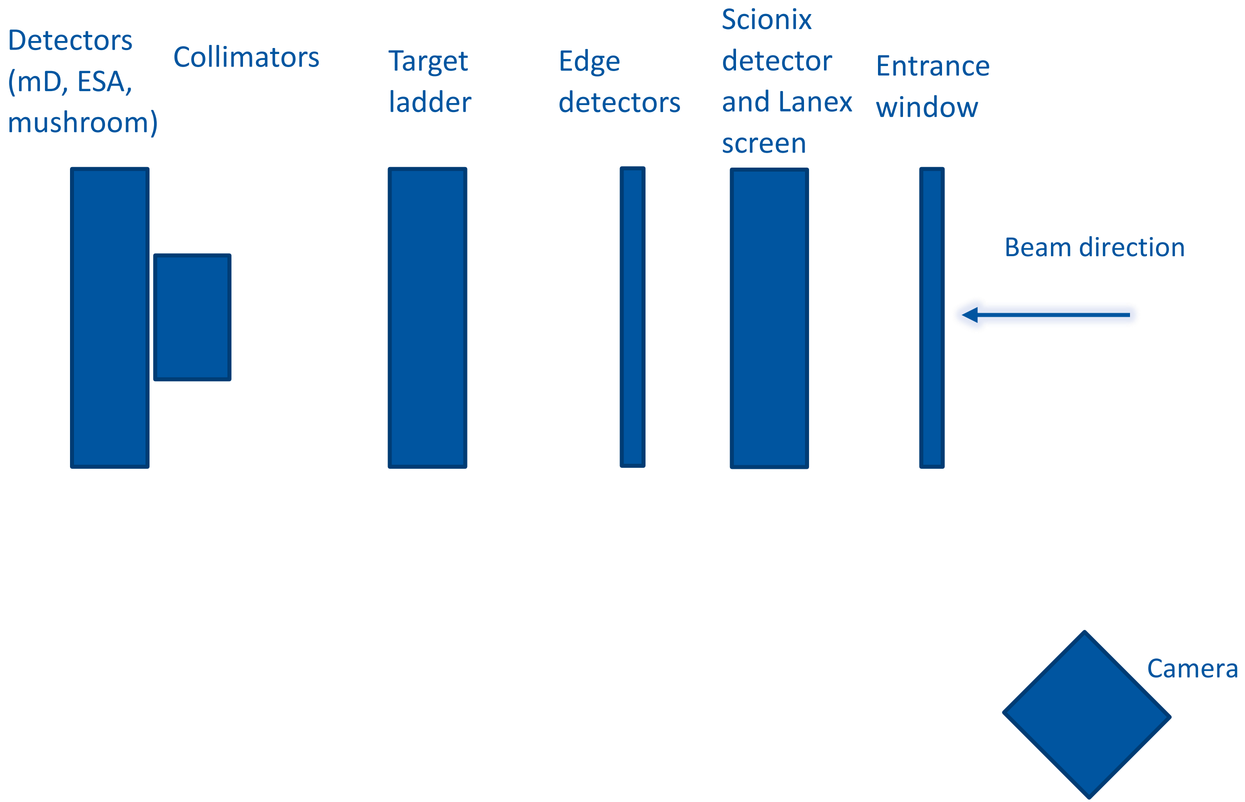
Design of the experimental set-up

- **Measurement under vacuum conditions**

- **Requirements for the vacuum chamber:**
  - Contain all detectors
  - Make image of the beam
  - Calibration
  - Flux determination
  - Heavy ion and proton measurements
  - Operation at different institutes

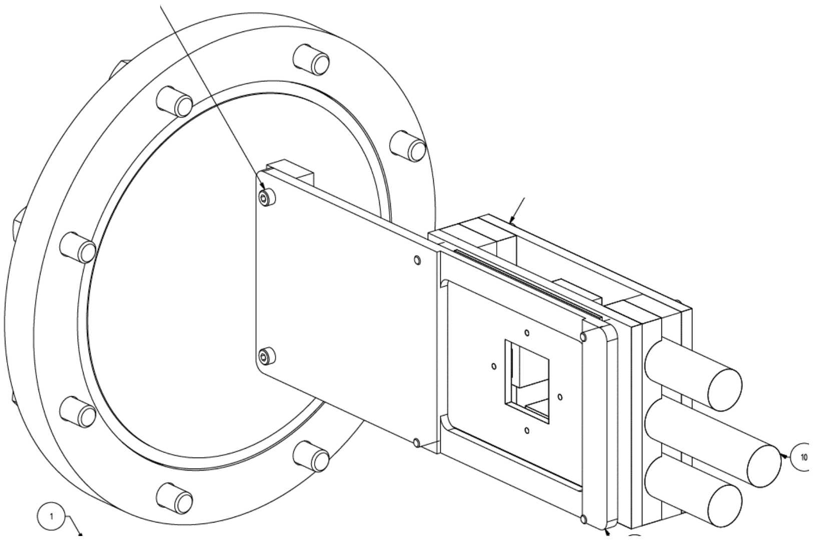


Component set-up



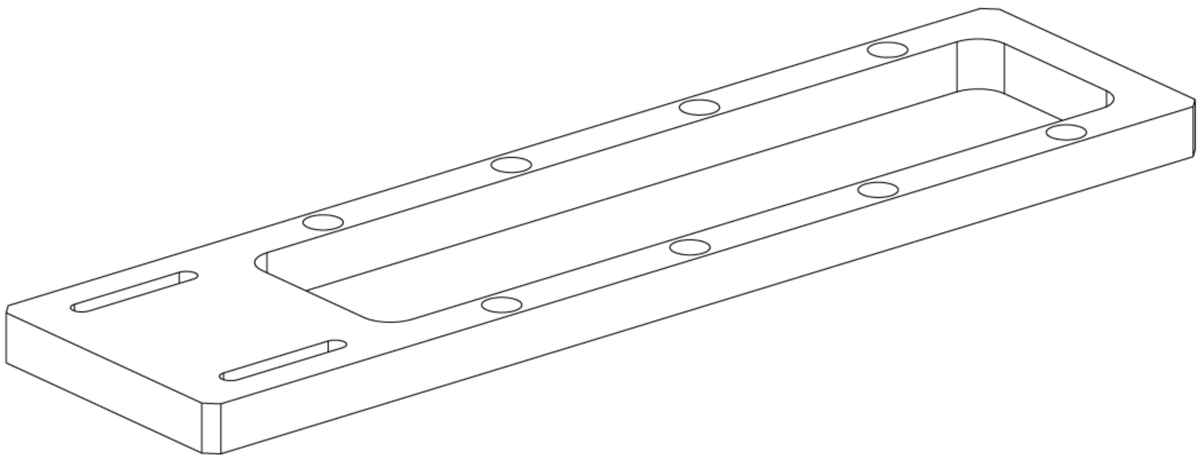
Field-edge detectors

- Four Scionix scintillation detectors with photomultiplier tubes



Target ladder

- Possibility to insert three different thin foils
- Connection to stepper motor

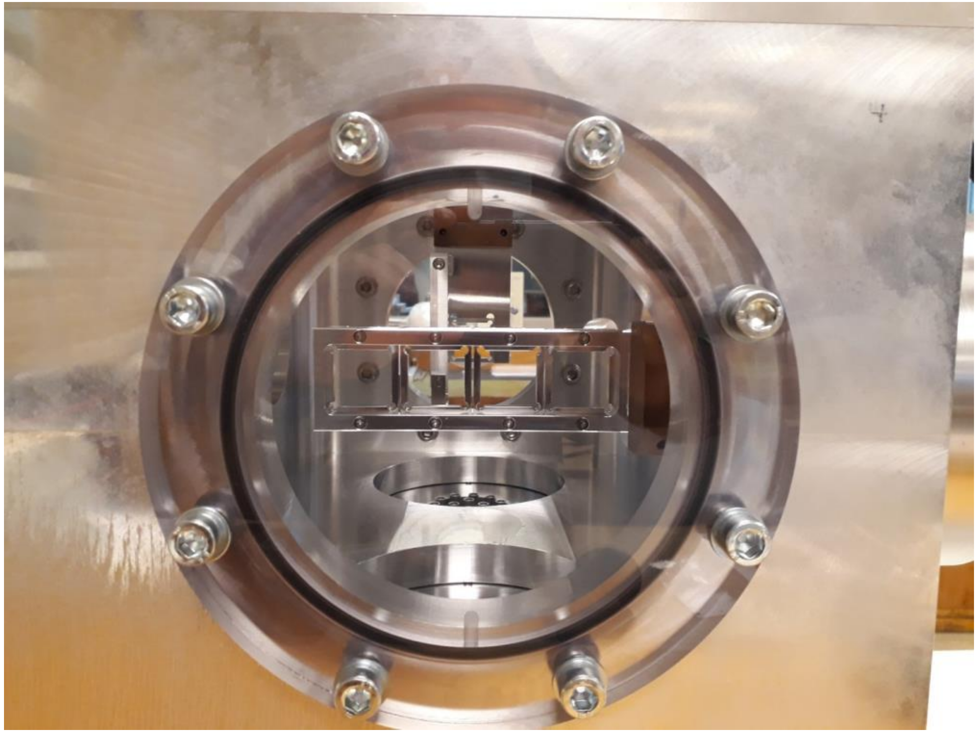


Stand-alone system

- Independent vacuum
- Connection to vacuum pipe at KVI possible
- Support frame with 40 cm height
- Entrance and exit foil

Construction progress

Construction progress



Summary and outlook

- Design of the vacuum chamber is completed
- Construction takes place at the moment
- A few mechanical problems have to be sorted out
- Experiments at KVI can hopefully start in late summer/autumn
- Vacuum chamber has an independent vacuum for use at other institutes
- Modify the set-up for use at different institutes

Bibliography

[1] Anatoly B. Rosenfeld. “Novel Detectors for Silicon Based Microdosimetry, Their Concepts and Applications”. In: Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Advances in Detectors and Applications for Medicine 809 (Feb. 11, 2016), pp. 156–170

[2] CMRP, CMRP MicroPlusProbe and MicrodosimetrySuite User Guide, Manual

[3] PTW Freiburg, MicroDiamond Detector, Brochure, accessed: 03.03.2020

[4] Grassberger, C., A. Trofimov, A. Lomax, and H. Paganetti. 2011. Variations in linear energy transfer within clinical proton therapy fields and the potential for biological treatment planning. *Int J Radiat Oncol Biol Phys* 80: 1559-1566